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ABSTRACT

Looking beyond the overall effectiveness of sensory stimulation, this study aimed to identify specific aspects of infant behavior most responsive to early stimulation. Subjects were 65 premature infants with a birth weight of less than 5 pounds, 8 ounces and a gestational age under 37 weeks. Experimental group members had completed a multimodal sensory stimulation program during their hospitalization; control subjects had not. Mental and Motor Scales of the Bayley Scales of Infant Development were employed in each infant's assessment. Discriminant analysis identified 22 items from these scales as predictors of membership in either the stimulated or unstimulated group; 18 items were from the Mental Scale, and four were from the Motor Scale. In general, the stimulated group had scores on both scales higher than those of the unstimulated group. Results also indicated that for some items there may be an inverse relationship between pass-fail scores and the child's chronological age, thus suggesting that the standard scoring procedure may be inappropriate. (RH)

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EFFECTS OF EARLY SENSORY STIMULATION ON THE PREMATURE INFANT AS MEASURED BY THE BAYLEY SCALES OF INFANT DEVELOPMENT

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INTRODUCTION AND REVIEW OF THE LITERATURE

Prematurity and low birth weight are two perinatal conditions which classify an infant as high-risk in terms of mortality and morbidity. Recent innovations and advances in neonatology, however, including the implementation of early stimulation programs, have improved the outlook for the high-risk infant. This study focused on early stimulation effects in the "healthy" premature infant and attempted to discern the aspects of behavior which were most responsive to early stimulation. The Bayley Scales of Infant Development (BSID) were used in behavioral assessment.

During the past ten years, advances in medical technology, obstetrics, and neonatology and the development of regional neonatal intensive care units (NICU's) with neonatal transport systems have contributed to the improved prognosis for premature and low birth weight infants (Schaefer, Hatcher, & Barglow, 1980). Despite the current state of the art in neonatal medicine, when compared with full-term infants, premature and low birth weight infants remain at a higher risk medically, emotionally, and developmentally (Schaefer et al., 1980).

Research strategies aimed at minimizing the impact of adversities associated with prematurity include early stimulation, environmental enrichment, and extra stimulation. According to Cornell and Gottfried (1976), early intervention programs are based on the assumptions that the premature infant is at a high risk for biological and psychological disabilities and that early hospital care is deficient in appropriate stimulation. Research supports the first assumption (Caputo & Mandell, 1970). However, Cornell and Gottfried disagree with the second assumption and contend that the people and equipment within the premature nursery provide a wide variety and a large amount of sensory experience.

Lawson, Daum, and Turkewitz (1977) agree with Cornell and Gottfried that hospitalized premature infants receive adequate amounts of stimulation, but argue that stimulation patterns are inappropriate. Schaefer et al. (1980) contend that Cornell and Gottfried neglected to account for both the types of stimulation and the infant's responses to monotonous stimulation. There is insufficient research to identify which conditions--adequate stimulation, inappropriate stimulation patterns, or sensory deprivation--best describe the environment of the hospitalized premature infant. The fact remains that the environment and early experiences of the high-risk infant are significantly different from those of the full-term infant (Masi, 1979).

Researchers studying the effects of early stimulation generally agree that programs for premature or other high-risk infants should begin in the NICU and should employ visual, tactile, auditory, kinesthetic, proprioceptive, or vestibular stimulation. Depending upon the researcher's interest, any one or a combination of sensory modalities may be stimulated through a number of techniques. Modalities used in stimulation programs include oscillating waterbeds (Korner, Kraemer, Haffner, & Cosper, 1975), tactile stimulation (Solkoff & Matuszak, 1975; Powell, 1974; Kramer, Chamorro, Green, & Kundtson, 1975), auditory stimulation (Katz, 1971), multimodal approaches combining various

techniques (Rose, Schmidt, Riese, & Bridges, 1980; Leib, Benfield, & Guidubaldi, 1980; McNichol, 1973), and home-based stimulation programs (Scarr-Salapatek & Williams, 1973; Rice, 1977).

A number of researchers have used the Mental and Motor Scales of the BSID as dependent variable measures in determining the effects of sensory stimulation on the development in the premature infant. Generally, differences between groups have been reported on the basis of the standard scores obtained from the Mental and Motor Scales, the Mental Development Index (MDI), and the Psychomotor Development Index (PDI), respectively. The study performed by Rice (1977) is the only one in which analysis fo the individual test items which comprise the Mental and Motor Scales was reported. In her study, analysis of variance was performed with the MDI and PDI scores as dependent variables and group membership--stimulated or unstimulated--as the independent variable. Then by using a Fisher's exact text, an analysis of individual items on both the Mental and Motor Scales through four months of age were made. Unfortunately, the appropriateness of Rice's statistical analysis is open to serious question since the number of individual comparisons, one per item, exceeded sample size.

Based on the studies that have been cited, whatever their approach to early stimulation and however the effects were measured, substantial support has been provided for positive effects of early stimulation. The main purpose of this study was to look beyond the overall effectiveness of sensory stimulation and assess what aspects of the infant's behavior, as measured by items of the BSID, were most responsive to early stimulation.

METHOD

Subjects

The subjects were premature infants whose records were on file at an infant development center in northeast Louisiana. Criteria for subject selection were: 1) a birth weight of less than 5 pounds, 8 ounces; 2) a gestational age of less than 37 weeks; and 3) an assessment with the Mental and Motor Scales of the BSID prior to a chronological age of 6 months. Infants with congenital anomalies, chromosomal abnormalities, or severe neurological impairments were not included in the study. Also, records dated before November, 1980, were excluded from the study.

The files of 397 infants were reviewed and a total of 65 subjects were selected on the basis of the above criteria. The subjects formed two groups, a stimulated group and a control group. Subjects in the stimulated group had completed the multimodal sensory stimulation program during their hospitalization, while control subjects had not participated in the program. The stimulated group consisted of 19 subjects, 11 males and 8 females. They had a mean birth weight of 3 pounds, 12 ounces and a mean gestational age of 32 weeks (8 weeks premature). The control group consisted of 46 subjects, 22 males and 24 females, and had a mean birth weight of 3 pounds, 11 ounces and a mean gestational age of 33 weeks (7 weeks premature).

Instrument

The Mental and Motor Scales of the BSID, developed by Nancy Bayley (1969), were the standardized scales employed in each infant's assessment. Both scales have been used frequently in studies of the effects of early sensory stimulation on premature infant development. The Bayley was chosen for this study because of its standardization, reliability, and broad representation of the many aspects of infant behavior (Collard, 1972).

The items of the Mental and Motor Scales of the BSID are arranged chronologically in tenths of months from 0.1 to 30+ months. The sums of item values on each scale provide estimates of the child's cognitive and motor development. Only responses to the first 48 items of the Mental Scale and the first 21 items of the Motor Scale were used since items beyond 48 and 21 were inappropriate for the developmental age of the subjects. These Mental Scale items measure vocalizations, manipulation of and play with objects, responses to visual and auditory stimuli, and responses involving social interaction. The Motor Scale items assess control of body and coordination of movements involving the head, arms, hands, and legs.

Procedure

A multimodal sensory stimulation program was implemented by hospital personnel in a regional Neonatal Intensive Care Unit (NICU) in September of 1982. After an infant's vital signs stabilize, sensory stimulation is begun in the NICU and is continued throughout the infant's hospitalization. The program is a multimodal stimulation program consisting of auditory, visual, proprioceptive-kinesthetic, tactile, vestibular, and olfactory stimulation presented once a day for approximately 15 minutes. Upon discharge from the hospital, the parents of each infant are referred to an infant development center where their child can receive a complete developmental assessment. The Mental and Motor Scales of the BSID are two components of this assessment.

Data were recorded from the files of infants who had been patients in the NICU and met the criteria for subject selection. An attempt to select files by using a table of random numbers failed because of the low proportion of useable files obtained after the first 85 files had been reviewed. Ultimately, it became necessary to use every available file.

Using the records of the infant center, subjects were assigned to one of two groups, a control group or a stimulated group. The control group consisted of premature infants discharged from the hospital prior to implementation of the stimulation program. The stimulated group consisted of premature infants who had participated in the stimulation program. Discriminant analysis was used to identify the items of the Mental and Motor Scales of the BSID which were most sensitive to sensory stimulation effects and thus allowed for the best prediction of group membership--control or stimulated.

RESULTS

The primary purpose of this study was to determine which items on the Mental and Motor Scales of the BSID were most sensitive to the effects of early sensory stimulation. To achieve this purpose, discriminant analysis was employed to identify which items best discriminated between the stimulated and unstimulated groups of infants. The mathematical objective of discriminant analysis is to weight and linearly combine the discriminating variables in an attempt to make groups as statistically distinct as possible (Klecka, 1975). When using discriminant analysis with two groups, the results are equivalent to multiple regression analysis (Kerlinger & Pedhazur, 1973). A combination of four items from the Motor Scale and 18 items from the Mental Scale contributed to the discriminant function which successfully predicted group membership. Chi-squared (83.72) calculated on Wilks' lambda (.20) was statistically significant at the .01 level of confidence. A statistical summary of the discriminant function is presented in Table 1. The discriminant procedure correctly classified 100% of the stimulated group and 95.7% of the unstimulated (control) group. Combining all subjects, an overall correct classification of 96.92% was obtained.

A stepwise entry of the items was employed. Items which were constants were deleted from the analysis. These items were numbers 1, 2, 6, and 7 on the Motor Scale and 1, 2, 3, 5, and 6 on the Mental Scale. Discriminant analysis was performed on 60 variables with 22 of these remaining after the final analysis. The set of 22 discriminating variables--scale items in this case--are presented in Table 3 with the corresponding F-to-remove values. These values represent the discriminating power carried by each item, above and beyond the contributions already made by the other variables (Klecka, 1980). The results indicate Motor Scale item 15 possesses the greatest degree of discriminating power, i.e., followed by Mental Scale items 31, 42, and 4, respectively. It is interesting to note that out of 22 discriminating items, only four items from the Motor Scale are represented, but that in the list of F-to-remove values, these four items are represented within the first 10 items. The fact that the contributions made by these items are relatively high, with respect to the contributions made by the other items, is not surprising. The assessment of development in a preverbal child must rely heavily, if not completely, on motorically based responses. A brief description of the Mental Scale items contributing to the discriminant function and group means for each item are presented in Table 4. An analogous table for Motor Scale items is presented in Table 5.

The standardized canonical discriminant function coefficients for each of the selected discriminant items are presented in Table 6. These coefficients indicate each item's contribution to the discriminant function. The results indicate Mental Scale item 31 made the greatest individual contribution with Motor Scale item 15 making the second greatest individual contribution and Mental Scale item 42 making the third greatest contribution. When compared to the F-to-remove values, the first three items are the same although items 31 and 15 are in reverse order.

DISCUSSION

The major purpose of this study was to identify items on the Mental and Motor Scales of the BSID which were most sensitive to the effects of early sensory stimulation. Discriminant analysis identified 22 items from these scales as predictors of membership in either a stimulated or an unstimulated group. It was hoped that an examination of these items would produce information regarding the nature of developmental changes which occur as a consequence of early stimulation in premature infants.

The group of discriminating items consisted of 18 items from the Mental Scale and four items from the Motor Scale. An examination of the group means for these items may aid in interpretation of the results (see Tables 4 and 5). The means of the stimulated group were higher on 11 of the Mental Scale items and on three of the Motor Scale items with means of the unstimulated group being higher on seven of the Mental Scale items and one of the Motor Scale items. In general, the stimulated group had higher scores than the unstimulated group on both scales.

When trying to assess the effects of stimulation as measured by each groups' performance on the discriminating items, it is difficult to provide a rationale as to why the stimulated group means were higher on some items and the unstimulated group means were higher on other items. However, a parallel can be made here with McNichol's (1973) findings. The subjects who received visual or tactile-kinesthetic stimulation in her study looked significantly less at visual stimuli than those who had not received visual or tactile-kinesthetic stimulation. This resulted in lower scores for stimulated subjects on the measure used to assess visual attention. Although the stimulated group scored lower than unstimulated controls, these lower scores could be indicative of a more mature visual processing ability.

With regard to the BSID, the items are presented in chronological order and each item is scored as pass or fail. If an item is passed, the child receives one point, but if it is failed, he receives zero credit. The sum of the passes are used to obtain the appropriate age equivalent scores as well as Mental and Motor Indices. The results of this study indicated that for some items there may be an inverse relationship between pass-fail scores and the child's chronological age. Therefore, the standard scoring procedure may be inappropriate in that it fails to consider the child's chronological or developmental age with respect to specific items he is passing or failing. At a certain age level if a child "passes" an item, it may actually indicate that development has not occured and that he/she should not be given credit for the item. In the same respect, if he/she "fails" the item sensory-motor integration may have occured and failure to produce that particular response may be indicative of a higher level of development than would production of the response.

This idea is parallel to a phenomenon which occurs in reflexive testing of central nervous system (CNS) development (Fiorentino, 1973). Reflex responses are associated with four levels of CNS development which occur in chronological order. Depending upon the chronological age of the child and the developmental level being assessed, at one age a

positive response can imply normal development while at later ages the same positive response can imply abnormal or delayed development. As Fiorentino states, positive responses persisting beyond a certain age level may be indicative of delayed maturation of the CNS.

An example of the inverse relationship which occurs with reflexive development is suggested in this study with regard to one of the four discriminating items from the Motor Scale. The unstimulated infants had a higher mean score on item 3, lateral head movements, than did stimulated infants. This is an innate response in which the newborn, when placed on his stomach, will turn his head to either side in order to breathe. On the basis of the inverse relationship phenomenon, sensory-motor integration of this innate response had occured for the stimulated infants. Therefore, they were performing at a higher level of development than were unstimulated infants because they did not have the higher mean score on this particular item. On the Mental Scale the same inverse relationship is suggested by responses to some of the discriminating items, although it is not as well defined as on the Motor Scale.

As outlined in the protocol of the stimulation program employed in this study (Dunn, 1982), emphasis was placed on developing symmetry of movement and body postures and encouraging midline oriented activities. The program is designed to foster cephalo-caudal and proximal-distal development. The stimulated group means were higher than the unstimulated on six items which were related to the performance of midline activities and proximal-distal development. These items were 15, 16, and 21 on the Motor Scale and 36, 37, and 45 on the Mental Scale.

It should be noted that the stimulation program had been implemented only eight months prior to this study. The results of this study suggest that positive results were obtained within a short period of time. Additional research is needed to assess the long-term effects of the program.

Further research is also needed to validate the findings of this study. Using the weights of each discriminating item as indicated by the discriminant function, a comparison of premature stimulated and premature unstimulated infants could be made to determine if these items remain the most sensitive to the effects of sensory stimulation and continue to provide the best discrimination between groups.

Considering the nature of infant development, it is indeed a difficult task to develop an instrument that provides an adequate assessment of infant development over a wide range of chronological and developmental ages. It is time to look at the instruments presently available and determine how they measure behavioral responses. If an inverse relationship does exist between pass-fail scores and the child's age, it is apparent a revision of the existing scale or the development of a new scale is needed.

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Table 1
Summary Table

Function	Eigenvalue	Canonical Correlation	Wilks' lambda	df	Chi-squared
1	4.00	.89	.20	22	83.72*

*Chi-squared calculated on Wilk's lambda significant at the .01 level of confidence.

Table 2
Subject Classification Table

Actual Group	N	Predicted Group Membership 1	2
Group 1 Stimulated	19	19	0
		100%	0%
Group 2 Unstimulated	46	2	44
		4.3%	95.7%

Overall Correct Classification: 96.92%

Table 3

Selected Discriminating Items and
F-to-Remove Values

Scale and Item Number	F-to-Remove
Motor 15	28.11
Mental 31	15.15
Mental 42	11.66
Mental 4	10.06
Motor 21	9.86
Mental 36	9.52
Mental 22	9.40
Motor 3	7.64
Mental 37	6.84
Motor 16	6.67
Mental 26	5.99
Mental 7	5.04
Mental 12	4.50
Mental 45	4.43
Mental 20	4.19
Mental 24	3.34
Mental 28	3.29
Mental 27	2.83
Mental 35	2.74
Mental 30	2.39
Mental 17	2.25
Mental 16	1.33

Table 4

Group Means of Discriminating Items from the Mental Scale

Item Number and Response Measured	Stimulated	Unstimulated
* 4 Responds to sharp sound	2.00	1.96
* 7 Prolonged regard of red ring	2.00	1.93
* 12 Vertical eye coordination-light	1.79	1.74
16 Circular eye coordination-red ring	1.53	1.72
* 17 Free inspection of surroundings	1.95	1.93
20 Turns eyes to light	1.58	1.72
* 22 Anticipatory excitement	1.89	1.83
24 Blinks at shadow of hand	1.32	1.63
* 26 Social smile: E smiles, quiet	1.63	1.50
27 Vocalizes to E's social smile & talk	1.68	1.70
28 Searches with eyes for sound	1.74	1.74
* 30 Vocalizes 2 different sounds	1.68	1.63
* 31 Reacts to disappearance of face	1.68	1.59
35 Anticipatory adjustment to lifting	1.26	1.50
* 36 Simple play with rattle	1.68	1.30
* 37 Reaches for dangling ring	1.16	1.11
42 Aware of strange situation	1.11	1.22
* 45 Inspects own hands	1.05	1.00

*Mean higher for stimulated group

Table 5

Group Means of Discriminating
Items from the Motor Scale

Item Number and Response Measured	Stimulated	Unstimulated
3 Lateral head movements	1.89	2.00
* 15 Hands predominantly open	1.74	1.28
* 16 Cube: ulnar-palmar prehension	1.63	1.30
* 21 Cube: Partial thumb opposition	1.05	1.02

*Mean higher for stimulated group

Table 6

Standardized Canonical Discriminant Function Coefficients for Selected Discriminating Items

Scale and Item Number	Coefficient
Mental 31	1.59
Motor 15	1.00
Mental 42	-.84
Mental 7	.78
Mental 22	.77
Mental 36	.75
Mental 4	.70
Motor 21	.69
Mental 26	.65
Mental 37	-.62
Mental 27	-.59
Mental 12	-.59
Mental 30	-.57
Mental 20	-.57
Mental 17	-.56
Motor 16	.55
Motor 3	-.49
Mental 28	-.44
Mental 35	-.40
Mental 45	.39
Mental 24	-.35
Mental 16	-.27

APPENDIX A

DATA COLLECTION SHEET

Case Number:_____

Date of Evaluation:_____

Group Membership: Stimulation No Stimulation

Sex: Male Female

Birth Weight:_____lbs. _____ozs.

Weeks Premature:_____

Chronological Age:_____months _____days

Developmental Age:_____months _____days

Mental Development Index:_____

Mental Age Equivalent:_____

Psychomotor Development Index:_____

Psychomotor Age Equivalent:_____

*Completion of the attached Mental and Motor Scale protocols.

*Bayley, Nancy. Bayley Scales of Infant Development. New York: The Psychological Corporation, 1969.